RESPONSES OF CAPTIVE BLACKBIRDS TO A NEW INSECTICIDAL SEED TREATMENT

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Abstract: Development of new repellent chemicals specifically to control crop damage by birds may be cost-prohibitive. Instead, the use of compounds developed for other pest control needs may be more practical. Thus, we conducted 2-cup feeding trials with singly caged red-winged blackbirds (*Agelaius phoeniceus*) and brown-headed cowbirds (*Molothrus ater*) to test the repellency of a new seed treatment insecticide, imidacloprid (proposed common name for Miles Incorporated NTN33893). Both redwings and cowbirds were strongly deterred ($P < 0.05$) from feeding on rice seed treated with imidacloprid at 620 and 1,870 ppm. When applied to wheat seed, imidacloprid effectively reduced ($P < 0.05$) consumption by redwings at rates as low as 165 ppm. We noted treatment-related effects such as ataxia and retching in some birds exposed to the highest treatment levels, but such effects were transitory. Videotapes indicated that imidacloprid was not a sensory repellent or irritant to birds. We conclude that avoidance of imidacloprid-treated food is a learned response mediated by postingestional distress. Although developed and envisioned as a broad spectrum, systemic insecticide, imidacloprid also appears to have promise as a bird repellent seed treatment.

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Bird damage to newly planted crops, such as rice, is a major problem for growers in the southern United States (Wilson et al. 1989, Decker et al. 1990). Despite the identification of potentially useful bird-deterrent seed treatments (e.g., Daneke and Decker 1988, Avery and Decker 1992), commercial development of such new management tools requires a substantial financial commitment (Tobin and Dolbeer 1987). These costs, and substantial regulatory expenses (Fagerstone et al. 1990), impose an economic burden that may be too high for application in most grain crops.

Compounds already marketed and registered for use against other types of agricultural pests may constitute a more economical source of bird damage control chemicals. For example, fungicides appear to have utility as bird repellent seed treatments (Babu 1988, Avery and Decker 1991). Certain insecticidal seed treatments also may possess bird repellent properties.

Imidacloprid, 1-[(6-chloro-3-pyridinyl)methyl]-4,5-dihydro-*N*-nitro-1-*H*-imidazol-2-amine, is a nitro heterocyclic insecticide projected for use as a seed treatment on various crops, including rice and wheat. Because preliminary data suggested that imidacloprid is repellent to birds (J. W. Mullins, Miles Inc., pers. commun.), we investigated its possible effectiveness as a feeding deterrent on these 2 grains.

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METHODS

Test Food

We adulterated rice seed with imidacloprid at 5 levels: 0, 70, 205, 620, and 1,870 ppm. Likewise, wheat seed was treated at 0, 55, 165, 500, and 1,500 ppm. The highest treatment rate for each seed type corresponded to the projected recommended rate on the pesticide label.

Test Procedure

Male red-winged blackbirds and brown-headed cowbirds were trapped and held in captivity 1–3 months prior to testing, during which time they had free access to F-R-M® Game Bird Starter and water. Four days before the start of the pretreatment period, we removed birds from their holding cages, determined their mass, and assigned them to individual test cages (45 × 45 × 45 cm) in an outdoor aviary. We formed treatment groups of 7 birds each by randomly assigning treatments to the cages. We tested red-winged blackbirds with rice and wheat and brown-headed cowbirds with rice seed. For the cowbird trial, we omitted the 70 ppm treatment level because the redwings displayed indifference to it. During the acclimation period, we provided the birds with 2 clear plastic food cups (8.2 cm diam, 3.2 cm high, with a 3.1-cm opening in the top), each of which contained a mixture of the untreated seed (rice or wheat) and Game Bird Starter.

Following acclimation, there was a 5-day pretreatment period, a 2-day break, and a 5-day treatment period. Daily during the pretreatment and treatment periods, we randomly assigned 1 cup in each cage as the treated cup. During pretreatment, both the treated and untreated food cup contained 30 g of untreated seed. In the treatment phase, the designated treated cup contained imidacloprid-treated seed.

Throughout the pretreatment and treatment periods, we removed Game Bird Starter at 0700, and 1 hour later put in the test food cups. After 3 hours, we removed the test food and provided 1 cup of Game Bird Starter. Spillage of test food collected on aluminum trays beneath each cage was measured daily.

We observed birds for indications of treatment-related effects such as vomiting or ataxia. We videotaped selected individuals exposed to the highest treatment rates to determine the birds' reactions to the treated seed. After the study the masses of all birds were re-determined and they were banded and released.

Analysis

For each bird, we estimated consumption by subtracting the mass of seeds in each cup after the trial from the initial mass and then adding the mass of spilled seed. We apportioned spillage between the 2 cups according to the amount removed from each cup.

Because we found no pretreatment differences in consumption among groups or between cups, we analyzed the 5-day treatment period only in a repeated measures ANOVA with group as the independent factor and day and cup as repeated factors. Tukey HSD tests (Steel and Torrie 1980) were used to isolate differences among means ($P < 0.05$). We analyzed changes in body mass from beginning to end of the experiment in a 1-way ANOVA.

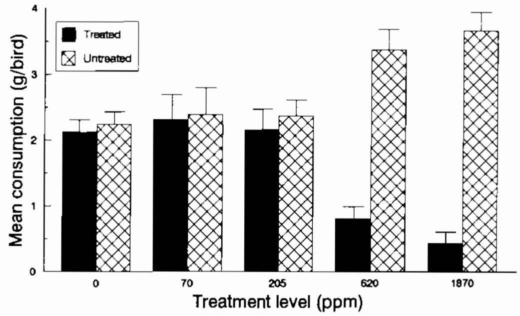

Fig. 1. Mean consumption of untreated and imidacloprid-treated rice seed by red-winged blackbirds during 3-hour feeding trials over 5 days. Capped vertical bars denote 1 SE. Consumption of treated rice was reduced ($P < 0.05$) in the 620 and 1,870 ppm groups.

RESULTS

Rice–Blackbird Trial

Consumption Data.—There was a day effect ($F = 6.09$; 4, 120 df; $P < 0.001$) with the lowest mean per cup consumption on the initial treatment day (1.9 g/cup) and the highest on the final day (2.4 g/cup). The interaction ($F = 2.03$; 16, 120 df; $P = 0.016$) between imidacloprid level and day indicated that this consumption pattern varied somewhat among the treatment groups.

Mean consumption from the treated food cup (1.6 g/bird) was less ($F = 34.03$; 1, 30 df; $P < 0.001$) than that from the untreated cup (2.7 g/bird). The interaction ($F = 9.67$; 4, 30 df; $P < 0.001$) between imidacloprid level and cup reflected the substantially reduced consumption from the treated cup by the 620 and 1,870 ppm groups (Fig. 1).

Body Mass.—Changes in body mass did not differ among treatment groups ($F = 1.32$; 4, 30 df; $P = 0.28$). Mean changes ranged from a gain of 0.5 g in the 70 ppm group to a loss of 1.0 g in the 1,870 group.

Behavioral Observations.—When we collected the food cups after day 1, 1 redwing in the 1,870 ppm group exhibited muscular incoordination. It could not stand up or stay on its perch. At 1 point, it lay on its back on the cage floor, then flopped over on its breast. When we checked again 90 minutes later, the bird appeared normal.

We videotaped this bird on the next 2 test days. Each day, it initially tried seed in the left

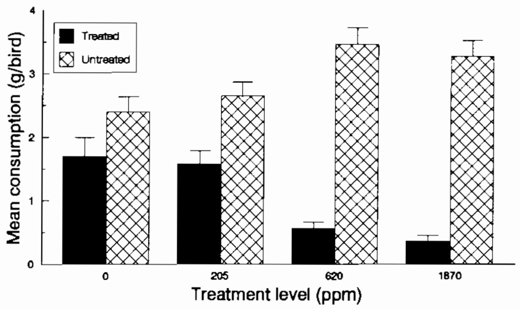

Fig. 2. Mean consumption of untreated and imidacloprid-treated rice seed by brown-headed cowbirds during 3-hour feeding trials over 5 days. Capped vertical bars denote 1 SE. Consumption of treated rice was reduced ($P < 0.05$) in the 620 and 1,870 ppm groups.

cup (on day 1, the treated seed was on the right). On day 2, it fed mostly on untreated seed in the left cup, but did sample the treated seed in the right cup. On day 3, the bird quickly moved from the left cup (treated) to the right one (untreated), and ate there almost exclusively.

A second bird that we videotaped on day 1 initially ate from both cups, but within 10 minutes it settled on the left cup (untreated). It exhibited no reaction to the treated seed.

Rice-Cowbird Trial

Consumption Data.—Mean rice consumption was affected by day ($F = 9.58$; 4, 96 df; $P < 0.001$). On days 1–3 consumption averaged 1.8 g/bird compared with 2.3 g/bird on days 4 and 5. Mean consumption from the treated cup (1.1 g/bird) was less ($F = 64.24$; 1, 24 df; $P < 0.001$) than that from the untreated cup (2.9 g/bird). The interaction ($F = 6.12$; 3, 24 df; $P = 0.003$) between imidacloprid level and cup indicated that consumption of treated rice was reduced ($P < 0.05$) when compared with untreated rice in the 620 and 1,870 ppm groups, but not in the 0 and 205 ppm groups (Fig. 2).

Body Mass.—Changes in body mass did not differ ($F = 0.46$; 3, 24 df; $P = 0.710$) among treatment groups. Mean body mass loss ranged from 3.4 g/bird in the 620 ppm group to 4.9 g/bird in the 205 ppm group.

Behavioral Observations.—We videotaped 2 cowbirds in the 1,870 ppm rice seed treatment group. On day 1, bird 23 immediately ate 3 or 4 treated seeds, but then moved to the untreated cup and returned only once to the treated seeds during the 57-minute observation period. We saw no reaction to the treated seed. Observations on days 2–4 revealed almost no use of the treated seed cup by this bird. During the 58-minute observation period on day 5, however, this bird spent 2.5 minutes at the treated cup and took 22 seeds. There was no indication of discomfort or irritation.

We videotaped bird 27 on days 3–5 only. Consumption data from days 1 and 2 indicated that it had not removed any treated seeds on those days. On day 3, however, this bird started eating from the treated cup (left side) and consumed 68 seeds in 13 minutes. Then, about 2 minutes later, the bird made a series of pronounced pumping movements as if attempting to vomit. The bird then sat quietly and did not appear otherwise distressed. Later in this 2-hour observation period, the bird returned to the left cup and ate several more treated seeds with no apparent reaction.

On day 4, the treated seed cup was again on the left side, and bird 27 ate from it for 11 minutes but displayed no distress. Then, it switched sides and ate from the untreated cup for 20 minutes. During the remainder of the 2-hour observation, it did not return to the left cup.

The treated seed cup was on the right side on day 5, and bird 27 ate from the treated cup for 7 minutes (30 seeds). Then, it switched to the untreated cup and fed there for 9 minutes. Approximately 15 minutes later, the bird appeared to retch, although the body movements were less emphatic than on day 3. During the remainder of the 2-hour observation period, the bird fed only from the untreated cup and showed no further signs of distress.

Wheat-Redwing Trial

Consumption Data.—Mean wheat consumption from the treated food cup (0.9 g/bird) was less ($F = 102.14$; 1, 30 df; $P < 0.001$) than that from the untreated cup (2.9 g/bird). The interaction ($F = 9.17$; 4, 30 df; $P < 0.001$) between imidacloprid level and cup reflected the increasing disparity in consumption between cups as the treatment level increased (Fig. 3). The 3-way interaction ($F = 1.73$; 16, 120 df; $P = 0.049$) indicated that while consumption from the treated cup was suppressed on each day at the higher treatment levels, this pattern did not hold on some days in the 0 and 55 ppm groups.

Body Mass.—Reductions in body mass did not differ among treatment groups ($F = 0.10$;

4, 30 df; $P = 0.98$). Mean mass loss ranged from 4.1 g/bird in the 165 ppm group to 4.7 g/bird in the 1,500 ppm group.

Behavioral Observations.—On day 1, we videotaped 1 bird in the 1,500 ppm group for 2 hours. Although this bird ate predominantly from the untreated cup (right side), it frequently visited the treated cup as well. On 16 occasions, it removed a single seed from the treated cup, took it across the cage, and ate it at the untreated cup. Twice, this bird fed at the treated cup for several seconds at a time, but at no time did it exhibit an adverse reaction to the treated seeds.

DISCUSSION

Imidacloprid effectively deterred feeding on rice and wheat seed at and below the proposed seed treatment application rates. None of the birds we observed exhibited any sign of distress or irritation when first eating treated seed. Thus, imidacloprid is not a contact irritant or primary sensory repellent like, for example, methyl anthranilate (Mason et al. 1989). Rather, repellency is caused by learning associated with post-ingestional distress. In this respect, imidacloprid resembles the effective bird repellent methiocarb that produces postingestional distress (Rogers 1978), but is not taste-aversive (Avery 1984). In fact, relative to controls, reductions in imidacloprid-treated seed consumption were comparable to those obtained using methiocarb in a similar test regime (Avery and Decker 1991: Fig. 1).

Unlike methiocarb, however, imidacloprid does not inhibit cholinesterase activity. Instead, imidacloprid, like related nitro heterocyclic compounds, competes with acetylcholine for receptor sites that can have both excitatory and inhibitory effects on the animal's nervous system (Taylor 1990). Presumably, such effects resulted in ataxia and other behaviors that we observed in some test birds. The observed effects were transitory, however, and all birds recovered completely in a short time.

Previous studies with mallard (*Anas platyrhynchos*) and northern bobwhite (*Colinus virginianus*) chicks indicated that dietary imidacloprid concentrations greater than 150–250 ppm were unpalatable (Miles Inc., unpubl. data). Because of differences in the testing protocols, it is difficult to compare our results directly with those LC_{50} study data. Nevertheless, the cowbirds in our study rejected rice treated at the

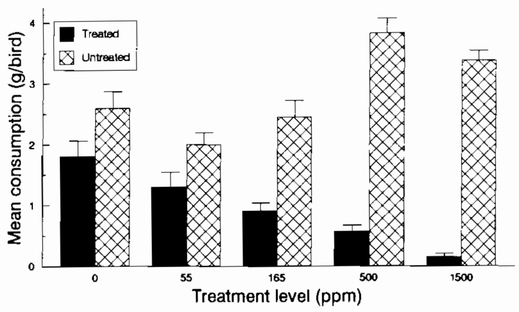

Fig. 3. Mean consumption of untreated and imidacloprid-treated wheat seed by red-winged blackbirds during 3-hour feeding trials over 5 days. Capped vertical bars denote 1 SE. Consumption of treated wheat was reduced ($P < 0.05$) in the 165, 500, and 1,500 ppm groups.

205 ppm level (Fig. 2) and redwings did the same to wheat at the 165 ppm level (Fig. 3). Although redwings showed indifference to the 205 ppm imidacloprid-treated rice, they did avoid higher concentrations (Fig. 1). The birds in our study probably did not ingest the total amount of imidacloprid applied to the seed because the birds did not eat the outer hull.

MANAGEMENT IMPLICATIONS

For crop protection, using a single compound for >1 problem has obvious advantages over developing separate chemicals for each target species. A multiple-use approach benefits not only the producer of the product but the users as well. Currently, imidacloprid is registered in France as an insecticidal treatment for sugar beet seeds. Insecticidal uses projected for the United States include turf as well as rice, wheat, and cotton seeds. Even though imidacloprid was developed to control certain insect pests (e.g., aphids, rice water weevil), our findings suggest that it is also an effective bird repellent. In fact, imidacloprid was an effective deterrent at application rates 60% less than that proposed for insecticidal use (J. W. Mullins, Miles Inc., pers. commun.).

Equally important to the prospective use of this seed treatment insecticide is the fact that no bird was seriously affected by feeding on the treated seed. Because the insecticide is not a contact repellent or irritant, birds have to feed on treated seed and experience the postingestional effects to learn to reject the seed. It seems possible that in the field, some birds will have prolonged feeding bouts on treated seed. We observed this in one of the cowbirds we tested with imidacloprid-treated rice, but the observed responses were temporary, and the affected bird recovered fully.

More extensive testing, such as in a flight pen and in planted fields, needs to be conducted before the feeding deterrence and avian hazards of imidacloprid are clearly defined. Based on the test results reported here, however, this seed treatment insecticide is promising in both respects.

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